

shown in FIG. 1, in the vehicle 1 having four wheels 3, the center of an on-the-spot rotation is located at the position of the geometric center of gravity of the four wheels 3, more specifically at a point of intersection between lines each connecting diagonally opposite wheels 3 to each other.

[0028] The steering device 4 provided for each wheel 3 is configured to be capable of steering the wheel 3 to at least 90 degrees to allow for a lateral travel, oblique travel, and on-the-spot rotation described above. Here, a steering angle is an angle to which the wheel 3 is steered from a direction orthogonal to an axis passing through the center of the wheel 3 in a width direction of the vehicle 1, i.e., from the front-rear direction of the vehicle. For example, the direction of steering of the right front wheel and the left rear wheel is leftward (a counterclockwise direction) in a top-down view of the vehicle body 2, and that of the right rear wheel and the left front wheel is rightward (a clockwise direction) in a top-down view of the vehicle body 2. The steerable angle may be 90 degrees in each of the counterclockwise direction and the clockwise direction, and thus 180 degrees in total.

[0029] Since the steering angle is set to such a large angle, or to allow for such a large steering angle, a driving unit 5 including a driving mechanism and a braking mechanism are provided for each wheel 3. Thus, the vehicle 1 in this embodiment of the present disclosure can be called a type of in-wheel motor vehicle (IWM). FIG. 2 is a schematic view illustrating an example of the driving unit 5 and the steering device 4. Inside a casing 6 of the driving unit 5, a motor 7 that outputs torque for traveling, a speed reducing mechanism 9 that amplifies the torque of the motor 7 and transmits the amplified torque to an output shaft 8, and a braking mechanism 10 are housed. To regenerate energy during deceleration, the motor 7 is formed by a motor-generator having an electricity generating function, such as a permanent-magnet synchronous electric motor. The speed reducing mechanism 9 is provided to downsize the motor 7, i.e., to make it possible to use a low-torque high-speed motor, and for example, a planetary-gear speed reducing mechanism that can be disposed coaxially with the motor 7 is adopted as the speed reducing mechanism 9. Such a speed reducing mechanism can be fixed by coupling the sun gear to the motor 7, the carrier to the output shaft 8, and the ring gear to a predetermined fixing part. Alternatively, the speed reducing mechanism 9 may be a so-called multi-shaft speed reducer with a plurality of gears meshing with one another.

[0030] The braking mechanism 10 may be any mechanism that can apply torque to the output shaft 8 in a direction of stopping the rotation of the output shaft 8, and one example is a friction brake. In the example shown in FIG. 2, the braking mechanism 10 is configured to prevent the rotation of the output shaft 8 through frictional force by clamping a disc 11, mounted on the output shaft 8, with a caliper 12. An actuator that drives the caliper 12 may be a hydraulic actuator, but an electromagnetic actuator may also be used. Adopting an electromagnetic actuator can reduce the number of members interfering with the wheel 3 and also simplify the configuration.

[0031] In a state of being rotatably supported on the casing 6 through a bearing 13, the output shaft 8 protrudes from the casing 6. A wheel hub 14 is provided at a protruding leading end of the output shaft 8, and a tire 15 is mounted to the wheel hub 14.

[0032] The driving unit 5 is mounted to the steering device 4, and the steering device 4 is mounted to the vehicle body

2 through a suspension arm 16. Thus, the driving unit 5 is supported by the vehicle body 2, and the wheel 3 is mounted to the vehicle body 2. A bracket extending on an upper side of the tire 15 is integrated with the casing 6 of the driving unit 5, and the steering device 4 is mounted at an upper end of this bracket. As described above, the steering device 4 is configured to be capable of steering the wheel 3 to about 90 degrees or about 180 degrees. One example of this configuration is schematically shown in FIG. 3.

[0033] The steering device 4 has a tubular casing 17, and the casing 17 is mounted to the suspension arm 16 such that a central axis L of the casing 17 is oriented substantially in a vertical direction and passes through a center of rotation of the wheel 3. Inside the casing 17, a steering motor 18 and a speed reducing mechanism 19 are disposed one above the other on the central axis L so as to face downward.

[0034] The motor 18 may be any motor that can output torque required to steer the wheel 3. It is preferable that the motor 18 be a low-speed high-torque motor and, to reduce the unsprung mass, be a motor having as small a weight per unit output torque as possible. The speed reducing mechanism 19 is a mechanism that amplifies the torque output by the motor 18, and can be formed by a planetary gear mechanism as with the speed reducing mechanism 9 of the driving unit 5. In the example shown in FIG. 3, a sun gear 19S is coupled to an output shaft of the motor 18, a carrier 19C is coupled to a steering shaft 20, and a ring gear 19R is mounted to the casing 17. Moreover, the driving unit 5 is coupled to a lower surface of the casing 17 through a thrust bearing 21, and the steering shaft 20 is coupled to the driving unit 5.

[0035] Thus, the steering device 4 is configured such that, as the motor 18 rotates, the driving unit 5 rotates along with the steering shaft 20, causing the wheel 3 to rotate around the central axis L of the steering device 4 as the rotational central axis. Specifically, the center of steering of the wheel 3 is the central axis L, and the central axis L is set so as to pass through the center of rotation of the wheel 3, so that the wheel 3 rotates around the two axes, one being the central axis of the output shaft 8 of the driving unit 5 and the other being the central axis L of the steering device 4. Since the steering device 4 is a device that steers the wheel 3 to a target angle, it is preferable that the steering device 4 be provided with a sensor (not shown) that detects a steering angle and configured to control the rotation angle of the motor 18 or the driving unit 5 by using a detection angle of this sensor as a feedback signal.

[0036] The wheel 3 mounted to the driving unit 5 is located inside a wheelhouse 22 that is provided as part of the vehicle body 2. The wheelhouse 22 is a partition wall that separates a region where the wheel 3 is disposed and an inside of the vehicle body 2 from each other, and covers an outer circumferential side (especially an upper side) of the wheel 3. The wheelhouse 22 has such a size that the wheel 3 fits inside the wheelhouse 22 when the vehicle 1 performs a so-called normal travel of traveling in an arcuate line with two wheels of either the front wheels or the rear wheels steered, but that the wheel 3 partially protrudes from the vehicle body 2 toward an outer side when the wheel 3 is steered to an extent enough to perform a special travel, such as a lateral travel or an oblique travel.

[0037] The driving unit 5 is electrically connected to a driving power supply unit 23, and the steering device 4 is electrically connected to a steering power supply unit 24.